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ABSTRACT

An analysis of journal articles from physics and molecular biology carried out with the help of six specialists in those disciplines reveals that scientists read journal articles by searching for the most newsworthy information, a behavior similar to that of newspaper readers. For this reason the scientific journal article is gradually taking on text features that promote surprise value, conventions analogous to those of news reports. Titles have become more informative, section headings and subheadings are more frequent, abstracts (which enable writers to foreground their most important claims) are becoming standard, visual aids are more rhetorically focused and attention-getting, introductions more frequently contain results, and methodology sections are de-emphasized, with background information often published in a separate genre--the review article. To meet the scientific community's imperatives of factuality and personal credibility, such fast-paced surprise-value oriented modifications of the traditional layout are offset by the discussion section. Here the writer restates the results, redescribes the gap in knowledge filled, compares findings with earlier results in a selective literature review, proposes implications for larger issues, and makes acknowledgements. Thus situating his novel findings within the body of knowledge previously accepted, the scientist reasserts his membership in the scientific discourse community. Helping students see such form-function correlations of discourse conventions is one way to "demystify" academic discourse. (JG)

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Surprise Value in Scientific Discourse

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In current writing pedagogy, audience analysis is usually taught by having students try to imagine particular readers with particular backgrounds, attitudes, needs, interests, and knowledge. This may make sense in transactional writing, e.g., technical writing and business writing courses, where students are expected to write letters, memos, reports, and other documents aimed at particular readers. In advanced academic writing, however, it makes less sense, for in academic disciplines, writers and readers are expected to subordinate their personal interests to the communally agreed-upon problems and epistemology of the field. Instead of ad hoc exigencies, one concerns oneself more with a body of knowledge. It is this body of knowledge, including the methodology used to expand on it, that attracts a readership. Hence, to understand one's audience as an academic writer, one must have a deep understanding of the subject matter that, in a sense, "creates" that audience. When we talk about academic discourse communities, then, we are talking in a very essential way about bodies of knowledge.

But knowledge, of course, does not rest immutable, even in the stodgiest of disciplines. It is constantly changing, constantly evolving, in response to a ceaseless flow of new ideas and findings. We know from studies by Bazerman, Myers, Gilbert and Mulkay, Latour and Woolgar, and others, that how these new knowledge claims are disseminated will determine, to a significant degree, how acceptable they will be to the

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discourse community and what effect they will thereby have on the disciplinary body of knowledge. We have to be aware, then, that academic discourse communities are held together not only by subject matter but by the ways in which this subject matter is discussed, that is, by discourse conventions. Indeed, on the assumption that there is a correlation between textual forms and communicative functions, we can use genre analysis to gain insight into the nature of discourse communities. As Douglas Park aptly puts it, "understanding the identity of the audience means understanding what readers expect, the nature of the 'conversation,' the conventions which govern that kind of prose. In particular, it usually means understanding the setting of publication . . . that ties those conventions to a specific format or to a set of assumed interests and attitudes in readers" (Park, 1986). If our students are to become good academic writers, we need to help them understand these conventions and the role they play in responding to audience expectations.

A good illustration of how genre conventions reflect the functioning of a discourse community can be found in scientific discourse. On the one hand, scientists subscribe to what Kinneavy (1971) calls "factuality," that is, to the degree of certainty that results from the use of well-established rules of inference and evidence and well-established quantitative methods. But scientists are also aware that absolute certainty is a chimera, and that so-called facts are always subject to revision. Hence they subscribe as well to the value of hypotheses, tentative findings, theoretical insights, and other less certain claims to knowledge, in short, to what Kinneavy would call "surprise value." Information does not have to contradict one's expectations to be surprising, but it does have to be new. Sociological and textual studies carried out by Gilbert and Mulkay, Bazerman, Myers, and

others have shown that scientists cannot expect their writing to have much effect unless it contains newsworthy information and thereby catches the attention of the writer's discourse community. But scientists cannot afford to pursue surprise value at the expense of their professional credibility; hence they must make rhetorical moves designed to promote both surprise value and factuality.

The purpose of this paper is to examine some of the textual conventions that scientists use to mediate the tension between surprise value and credibility. Specifically, I will be talking about a genre that is one of the primary written vehicles for the dissemination of new scientific knowledge and which has received considerable attention from discourse analysts in recent years -- the scientific journal article. What I have to say is based on an analysis of articles from the most important journals in molecular biology and physics, carried out with the help of six specialist informants from those disciplines. All six of these scientists are active researchers who regularly read these journals and frequently contribute to them; several of them serve on their editorial boards. I will make the following claims:

1. Scientists read journal articles in their specialty much as people read front-page news reports, searching for the most newsworthy information.

2. In response to this reading behavior, scientific journals are gradually modifying their genre conventions.

3. A major rhetorical purpose of the Discussion section, a critically important yet little studied section of journal articles, is to reassert one's membership in the discourse community by trading surprise value for community knowledge.

In my discussions with these scientists, I focused on two general types of questions: (1) How do you select and read journal articles? and (2) Is there anything special you do as a writer to catch the reader's attention and promote your ideas? Bazerman has already studied the reading behavior of three types of physicists, noting that they read selectively rather than sequentially, looking mainly for novel results (Bazerman 1985). I was interested in seeing to what extent his findings generalized to other types of physicists and to molecular biologists. More importantly, though, I wanted to see how a scientist's reading behavior might influence his or her writing behavior, both individually and collectively. I was especially interested in seeing how the text features I had noticed helped convey both surprise value and factuality.

All six of these scientists readily agreed that surprise value was an important, indeed necessary, component of journal articles. When I asked them to demonstrate how they customarily read a newly-published article in their field, they all displayed a reading pattern dominated by the search for new information. First they read the title, then the abstract, then they looked for the most important data, usually in graphs, tables, drawings, and other visual aids. Next they typically read the Results section. At this point their reading patterns varied, depending on how well they knew the topic and how confident they were of the scientific methods used. Sometimes they would read the Discussion section, sometimes they would read a paragraph or two in the Introduction. Time permitting, some would go back to the beginning and read the article straight through.

This reading pattern is strikingly similar to that displayed by newspaper readers. Newspaper readers look for the most surprising, most

newsworthy information first (i.e. the headline statement). Then they look for other information in descending order of news value. If photos are present, they will certainly look at those. Newspaper editors and reporters have long been aware of these preferences, of course, and have created a virtual text schema reflecting this pattern. Van Dijk (1986), after analyzing hundreds of newspaper reports, has described this schema as follows:

Headline Lead	Summary
Main event Details of main event Background Consequences Comments etc.	News Story

noting that this is a tendency, not a strict rule of order. It is easy to see an analogous progression of text segments for the reading pattern of scientists reading journal articles:

Headline	=	Title
Lead	=	Abstract
Main event	=	Major findings (e.g. Visual Aids)
Details of main event	=	Results
Background	=	Introduction
Consequences	=	Discussion
Comments	=	Implications
etc.		etc.

But whereas the textual layout of news reports mirrors almost exactly the anticipated top-down reading pattern, the textual layout of scientific journal articles, of course, is quite different. The traditional sequence of Introduction - Method - Results - Discussion reflects the chronology of idealized scientific procedure, not necessarily the chronology of reading.

This discrepancy between what we might call a narrative, writer-based text-schema on the one hand and a highly selective, purpose-driven

reading schema on the other is not seriously dysfunctional. Since the text schema is quite standardized, experienced readers know where to look for certain information and can skip around quite efficiently. Furthermore, when reading articles out of their specialty, most of them read in more of a top-down manner, giving more importance to the Introduction. In this case there was no particular discrepancy.

But the discrepancy between their specialist reading schema and the traditional text schema is clearly non-optimal. After all, the reader has to search for information, rather than just proceeding top-down. The only text features that facilitate a top-down approach are the Title and Abstract, which appear first and are read first (but which, it should be noted, are often written last). Newspaper articles, by contrast, are noticeably reader-based: instead of recounting a narrative of events chronologically, they pick out the most surprising information and put it up front. This tactic not only helps catch the reader's attention, it also facilitates selective reading. If pressed for time or only mildly interested in a topic, readers can terminate their reading after only the first few paragraphs and still have the gist of a story. Some newspapers, like *USA Today*, are designed to appeal to precisely this kind of reader.

But exactly which type of reader are these scientific journals aimed at -- the specialist or the nonspecialist? If the specialist, then we would expect them to modify their genre conventions somewhat so that the text schema conforms more to the reading schema. If the nonspecialist, there is no obvious need to make any modifications, since the two schemata are already in close alignment. My research indicates a clear trend in favor of the specialist. This century and especially the past decade have seen a number of subtle but, I believe, significant changes in the text-conventions

of the genre. Bazerman (1984 and ms.) has described a number of the changes that have occurred in the experimental physics article during the past 320 years, pointing out especially how changing genre conventions reflect a changing, more theoretically- and socially-oriented epistemology. I wish to add to his observations by pointing out ways in which scientists more recently have been adopting genre conventions designed to promote surprise value, i.e., news.

First, titles have become more informative. Twenty years ago, titles were almost strictly topical. Here is one, for example, from a 1967 issue of *Proceedings from the National Academy of Science:* "On the specificity of DNA polymerase." Today, one can expect to find something like this, from the same journal: " Rho-dependent transcription termination of a bacterial operon is antagonized by an extrachromosomal gene product." Not only is the newer title semantically richer, it also has the syntactic form of a full sentence. As recently as ten years ago, full-sentence titles like this were rare; today, in biology at least, they constitute more than 20% of all journal article titles. This may not equal the high percentage of full-sentence headlines found in newspaper articles, but it certainly shows a trend in that direction.

Informative section headings and subheadings also appear with greater frequency. They are used especially to announce results, and, in this role, they also commonly have the form of full sentences. Here too there is a striking parallel with news reports.

Abstracts, which enable writers to foreground their most important claims, used to appear only in certain journals. Now, however, they are a

standard feature of almost all scientific journal articles and even of quick reports and letters.[1]

Visual aids have always been a prominent feature of the modern scientific journal article, but, as Bazerman (1984) has noted, they have become more rhetorically and theoretically focused. Instead of tables of raw data, one more often today finds graphs, line drawings, schematic diagrams, and, in biology papers, photographs. These kinds of visual aids are all more visual than tables, and hence more attention-getting, just as photographs are in newspapers.[2]

The Introduction has not been changed in its physical location, but it has been changed in terms of the amount of "bottom-line" information that can typically be found in it. Swales and Najjar (n.d.), in a survey of 66 *Physical Review* articles published between 1943 and 1983, found that statements of results appeared with increasing frequency, from 36% in 1943 to 44% in 1963 to 55% in 1983.

To create more space for all this foregrounded information, most of these journals have shifted to a larger page-size. Readers of *Cell, Nature, Physical Review Letters, J. Biological Chemistry,* and *J. Molecular Biology*, for example, can now take in almost all of a paper's major findings and claims, both in writing and in visual aids, without having to turn more than one page.

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[1] *Physical Review* began using abstracts in 1920, but the other major journals in these two fields started much later: *J. Cell Biology* in 1958, *J. Molecular Biology* in 1959, *Biochemistry* in 1962, *J. Biol. Chem.* in 1966, *Physical Review Letters* in 1967, and *Nature* in 1970.

[2] One of my biology consultants informed me that one reason for this improvement in visual aids is the advent of the personal computer, which has made it possible for many authors to draw their own graphics.

Methodology sections, once given much space and prominence, are now greatly de-emphasized. In some journals, the Methods section is the only one printed in small type. In others (e.g. *Cell*, one of the most prestigious molecular biology journals), the Methods section not only appears in small print but has been physically relocated to the end of the body of the article, just before the acknowledgments paragraph. At least one major journal (*The Journal of Biological Chemistry*) has recently begun printing the Methods section at the very end of the paper, as a kind of supplement, in "miniprint." The editors note that "miniprint is easily read with the aid of a standard magnifying glass." In still others (e.g. *Nature*, one of the two most prestigious journals in the natural sciences), there is no methods section at all. Instead, the experimental methods are described in small print as part of the captions to figures.

Less important data, especially raw data, is also frequently relegated to a non-prominent position in the article, if it is there at all. *The Journal of Biological Chemistry*, for example, has recently started putting all but the most important data and figures at the end of articles, in miniprint.

Literature citations and other background information are less prominent in today's scientific journal articles than they used to be. Instead, background information is being published more and more in the form of review articles. *Cell* has recently created a new genre, the "mini-review," which has a much faster turnaround time and is therefore more up-to-date.

These changes bring the journal article as a genre closer to a related genre with which, in a sense, it "competes," namely, the Quick Report or Letter (sometimes called a Communication or Accelerated Publication). This latter genre, with its faster publication time, has generally become the

primary mode by which major breakthroughs in physics and biology are officially announced. By taking on more importance in the competitive, fast-paced world of modern science, it has also taken on more prestige. As such, it has increasingly been accorded the text features of regular articles. *Physical Review Letters* is the classic case in point. Originally published as ordinary letters to the editor in early editions of *Physical Review*, they began having the authors' names printed under the title in1941, started having larger type in 1955, were published separately in1958, began having abstracts in 1967, started having each letter begin on a new page in 1980, and began using large page size in 1985. In short, they have become increasingly conventionalized.[3] But they have done so by adopting only some of the traditional features of regular articles, namely, those that help carry surprise value, such as an informative title, a results-oriented abstract, powerful visual aids, and prominent statements of findings and claims; less newsworthy information relating to methods, materials, and raw data is usually omitted entirely. It is as if the journal letter, as a genre, has evolutionarily leapfrogged over the journal article in terms of combining surprise value and respectability.

All of the features discussed above serve to foreground important, newsworthy information by bringing it closer to the beginning of the article. In this respect, the scientific journal article is gradually taking on text features that are analogous to those of news reports, and in so doing is conforming more to the actual reading practices of working scientists. In an increasingly competitive world where they are deluged with information,

[3] One of my physics informants, who publishes regularly in both *Phys. Rev.* and *Phys. Rev. Letters* and also serves as a referee for both journals, says that the latter is far more conventionalized than the former.

scientists must read quickly and efficiently. A "top-down" layout of important information facilitates a selective reading process.

Whatever changes take place, however, will almost certainly occur through slow evolution, for there is strong countervailing pressure to retain at least a semblance of the traditional, writer-based narrative schema. The primary role of the scientific journal article, after all, even more important than conveying new knowledge claims to the scientific community, is the certification, so to speak, of these claims. The initial dissemination of claims can be done in other ways, e.g., through meetings, phone calls, proposals, and preprints. It is only through journal article publication that scientists can provide complete scientific argumentation for these claims. Hence, there is obvious pressure on them, in this genre, to promote factuality and personal credibility. One way of doing this is by using the traditional narrative schema, which symbolizes adherence to what Gilbert and Mulkay call the "empiricist repertoire." This means, of course, that whatever rhetorical moves most scientists make to get the attention of their readership will have to be small ones, done discreetly within the conventional formats currently in use. Only powerful, well- established scientists can successfully challenge the existing genre conventions in any major way.

The Discussion section. This tension between credibility and surprise value can be seen not only in the text features described above but also in the kinds of rhetorical "moves" that are made in specific sections of articles. John Swales (1981), for example, has shown that Introductions are typically composed of four distinct moves:

1. Assert the importance of the area of research.
2. Summarize selectively the relevant literature.

3. Show that there is something important that the existing literature does not account for, that there exists some "gap."
4. State the purpose of the present study in such a way that it is seen as filling the gap described in move 3.

Swales sees these moves as performing a "public relations" role, in the sense that the writer tries to show that her research is addressing an important problem in an interesting and useful way. In other words, the Introduction must show something of surprise value (either by offering some new and possibly unexpected solution to an established problem, or by raising a new problem) and it must establish the writer's credibility (by showing familiarity with past efforts to deal with this problem). Follow-up studies by Crookes (1984), Dudley-Evans (1986), and others have supported the essential correctness of Swales' observations with regard to articles in the natural and physical sciences.

Little attention, however, has been paid to the Discussion section of journal articles, which is unfortunate since, if we can generalize from my interviews with scientists who read these articles most closely, the Discussion section appears to be at least as important as the Introduction. All six of my consultants read at least part of the Discussion, while only a few of them read the Introduction.

If we apply a Swales-type analysis to the Discussion sections of journal articles, we find basically the same four types of moves as in the Introduction, but in reverse order. First, there is typically a statement of "bottom-line" results. One of my biologists, who serves on the editorial board of a major journal in the field, said that the first paragraph of the Discussion should always be reserved for the strongest claim in the study. Though he stated this as a prescription, my survey of papers in both biology

and physics showed it to be a description of actual practice anyway. Then there is a series of statements showing how these results respond to the larger issue stated in the Introduction. Next there is typically a comparison of the present results to related findings or claims made by other investigators; the present results are of course shown to be superior. Finally, the implications of the study may be stated, along with a statement of plans for future work. In the past, this was the place for speculation, but my consultants tell me that the competitiveness of science today and the emphasis on hard data have led to a major reduction in published speculation. Acknowledgements are also stated here.

That these four moves are analogous to those of the Introduction, but in reverse order, can be seen by doing a pairwise comparison:

Introduction	Discussion
4. gap-filling statement, w/ results	1. statement of major results
3. description of gap	2. redescription of gap, explanation of how results fill it
2. selective literature review	3. selective literature review, comparing present results with earlier ones
1. statement of importance	4. implications for larger issues (i.e. statement of possible importance for future); acknowledgments

In their normal 1-2-3-4 ordering, the four moves of the Introduction can be seen as working "from outside in": first addressing the field as a whole, then progressively narrowing the scope so that only the current

investigation is being talked about. In this way, the writer situates his work within the interests of the discourse community. Having established his "credentials" through moves 1-3, he is in a good position to offer newsworthy information in move 4. Moves 3 and 4 can be seen too as steps away from the consensual knowledge of the discipline.

Conversely, the four moves of the Discussion can be seen as working "from inside out": the writer begins by referring only to the study at hand, but then progressively widens the scope to include related work by others. In doing so, the scientist implicitly attempts to situate his novel findings within the body of knowledge previously accepted by his discourse community. Even the acknowledgments can be seen in this light. Acknowledgments have become increasingly institutionalized over the years, more often citing funding agencies instead of colleagues (see Bazerman 1984). In the highly competitive world of modern science, such acknowledgment of major institutional support implicitly reiterates the claim made at the beginning of the Introduction that this is an important research area worthy of the attention of many.

Conclusion. The analysis of scientific discourse put forth here suggests that front-line research scientists belong not to one but to two discourse communities, one embedded within the other. The traditional layout of the journal article, still in effect in many ways, symbolizes the scientist's membership in the larger scientific community. According to this layout, the background information and methodological details are presented as being as important as any other section of the article, which is consistent with their importance in the empiricist repertoire. But the gradual modifications of this layout that have taken place over time reflect the

scientist's membership in a smaller community, the more personal fast-paced one in which he plays a bigger role. Here there is little interest in background orientation and methodology, both of which are already familiar to him; instead, the scientist wants the "news." The modified genre conventions that we have examined here acknowledge this fact.

I agree with Bizzell (1982) that we need to "demystify" academic discourse for our students. One way of doing this is by helping them see the form-function correlations of discourse conventions.

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